



# PHRaGMENT

**Phobos Hyperspectral, Radiation, Gravity, And  
Magnetometry Experiment using Nanosat Technology**

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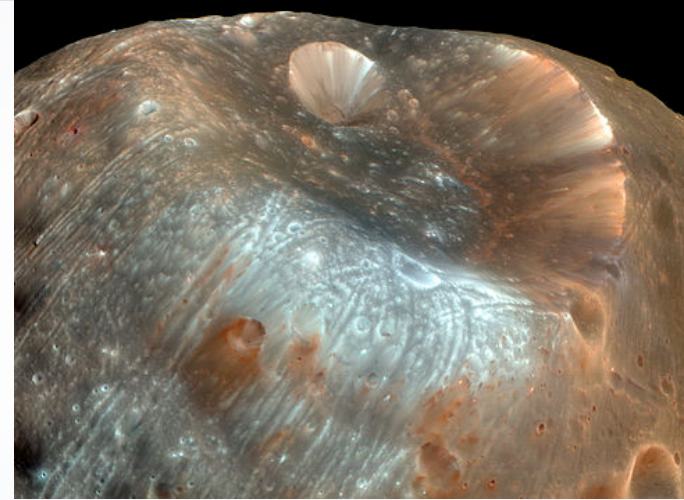
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# Why Phobos?

- Relatively unexplored
- Limited data from past missions
- Regolith may contain ejecta
- Similarity to other small bodies
- Origin of Phobos unclear
- Potential manned mission destination, in preparation for a future manned Mars landing
- No dedicated Phobos related activities planned for Mars 2020 and 2022 missions



# Motivation

"We do not know enough about the physical conditions near/at the surface of the Martian satellites low (**gravity**/loose regolith, etc.) ...to be able to design close proximity and surface interactions..." P-SAG Objectives (P. 24)

"...the compositions (and likely origins) of the Martian moons Phobos and Deimos may be relevant to understanding the **early history of Mars**" -- NRC Decadal Survey (P. 112)

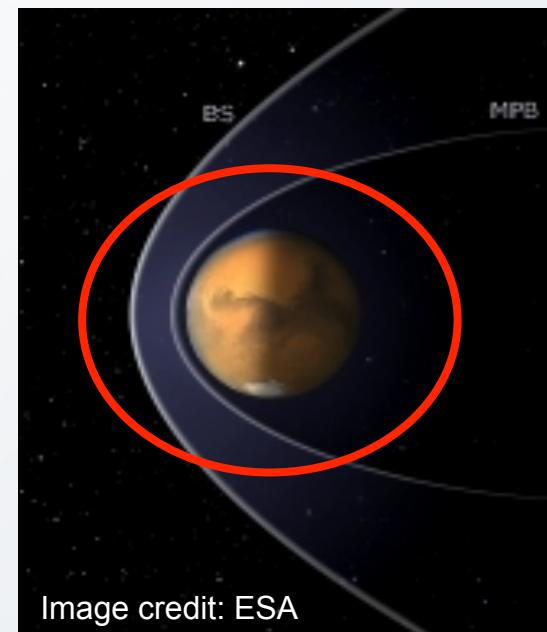
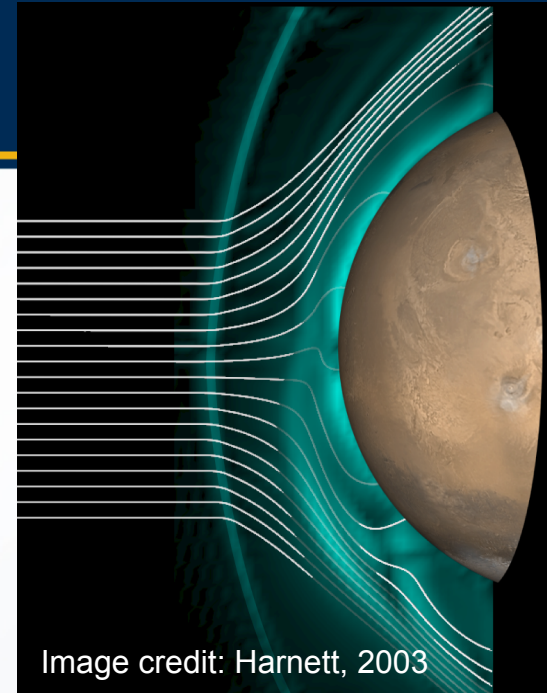
"We do not have enough understanding of the geological, **compositional** and geophysical properties of Phobos and Deimos..." P-SAG Objectives (P. 24)

"Because Phobos and Deimos are potential staging areas and sources of resources for future human exploration of Mars, missions to Phobos and Deimos would contribute to **human exploration** in a way unique among missions to primitive bodies" -- NRC Decadal Survey (P. 121)

- National Research Council. *Vision and Voyages for Planetary Science in the Decade 2013-2022*. Washington, DC: The National Academies Press, 2011.
- Analysis of Strategic Knowledge Gaps Associated with Potential Human Missions to the Martian System: Final report of the Precursor Strategy Analysis Group (P-SAG), 2012

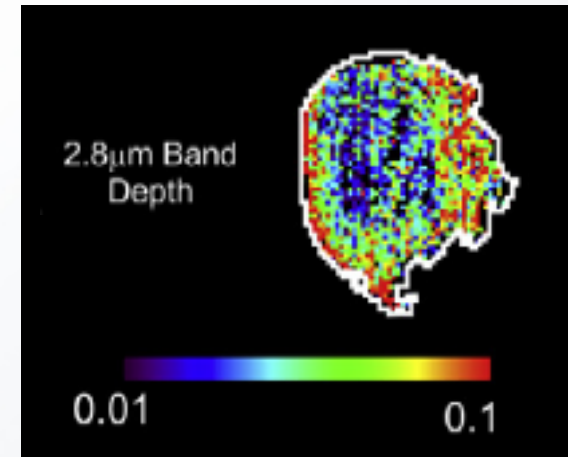
# Magnetic field

- Fobos-2 mission briefly detected faint magnetic field
- Confirmation would provide insight into the composition and origin of Phobos
- Any detected field would suggest remnant magnetization
- Characterize solar wind at Phobos
- Would observe boundary layer crossing of Mars' solar wind interaction
- Can be accomplished with (fluxgate) magnetometer and radiometer



# Hyperspectral Imagery

- Provides investigation of regolith composition
- Spectral bands can be chosen to address specific theories on Phobos' origins
  - 2.3  $\mu\text{m}$  band to capture clay
  - 1.9  $\mu\text{m}$  band for hydrated minerals
  - 1.0  $\mu\text{m}$ , 2.0  $\mu\text{m}$  bands for pyroxene and olivine



Fraeman et al, Icarus, 2014

- COTS instrument options exist for NIR and visible imager
- Possible to complement with thermal, x-ray, gamma-ray, altimeter, etc.

# Quasi-synchronous Orbit (QSO)

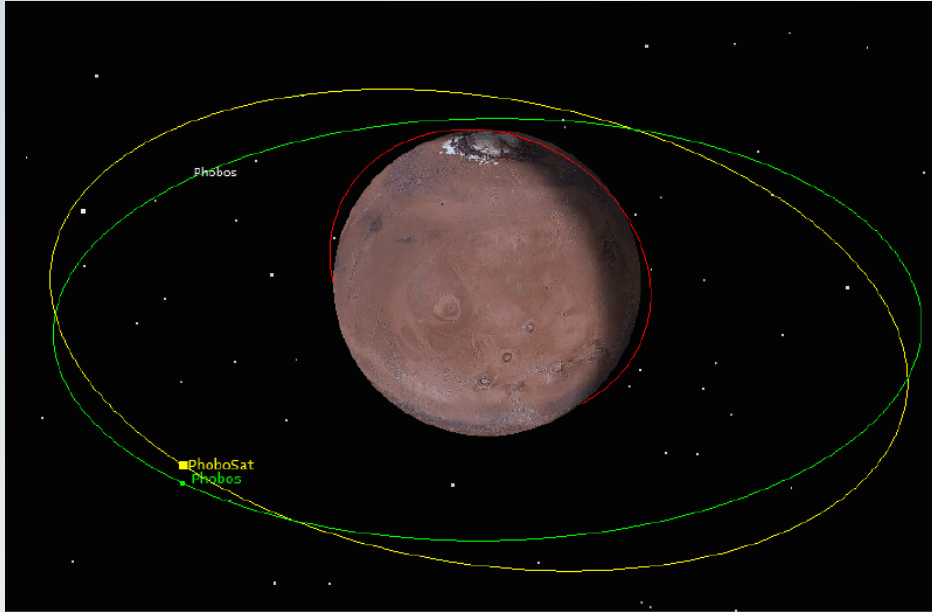


Image credit: B. Kumar, E. Srnka, S. Kuckelman, S. Chodimella, D. Ma, J. Cheung

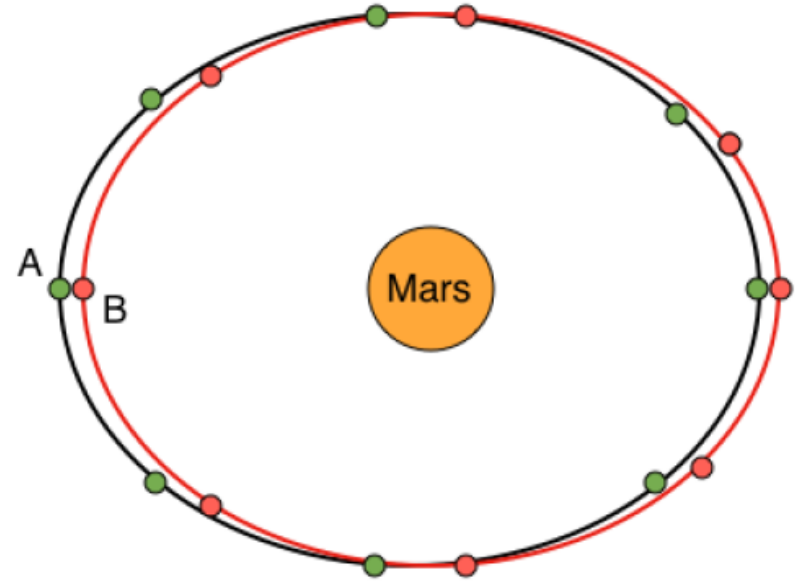


Image credit: S. Lympny, W. Jefferson, L. Smith, A. Garcia Garriga, A. Grubb, J. Paulson

- Relative distance of PHRaGMENT to Phobos varies between 100 – 400 km
- Delta-V required to reach Phobos from a representative equatorial insertion orbit  $> 500$  m/s

# Alternate orbit

- Orbit strategy also possible for a polar orbit deployment
- Revisits reduced to once every 5 orbits (23 hrs, 3 min)

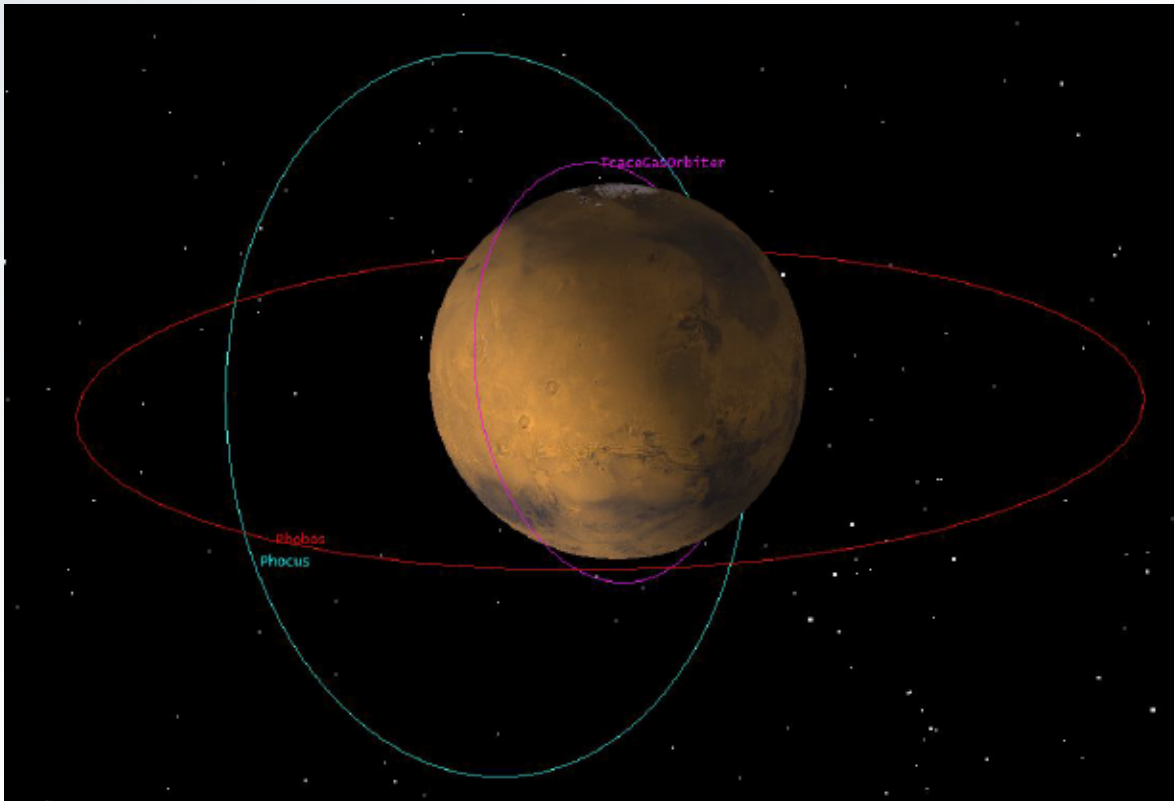


Image credit: A. Karlapudi, J. Ginn, E. Dale, L. Dressel, N. Tyman, Y. Guan, L. Lewis

# Conceptual Spacecraft Design

- Both 6U and 12U configurations explored
- Comms to existing orbiting asset (e.g., MRO)

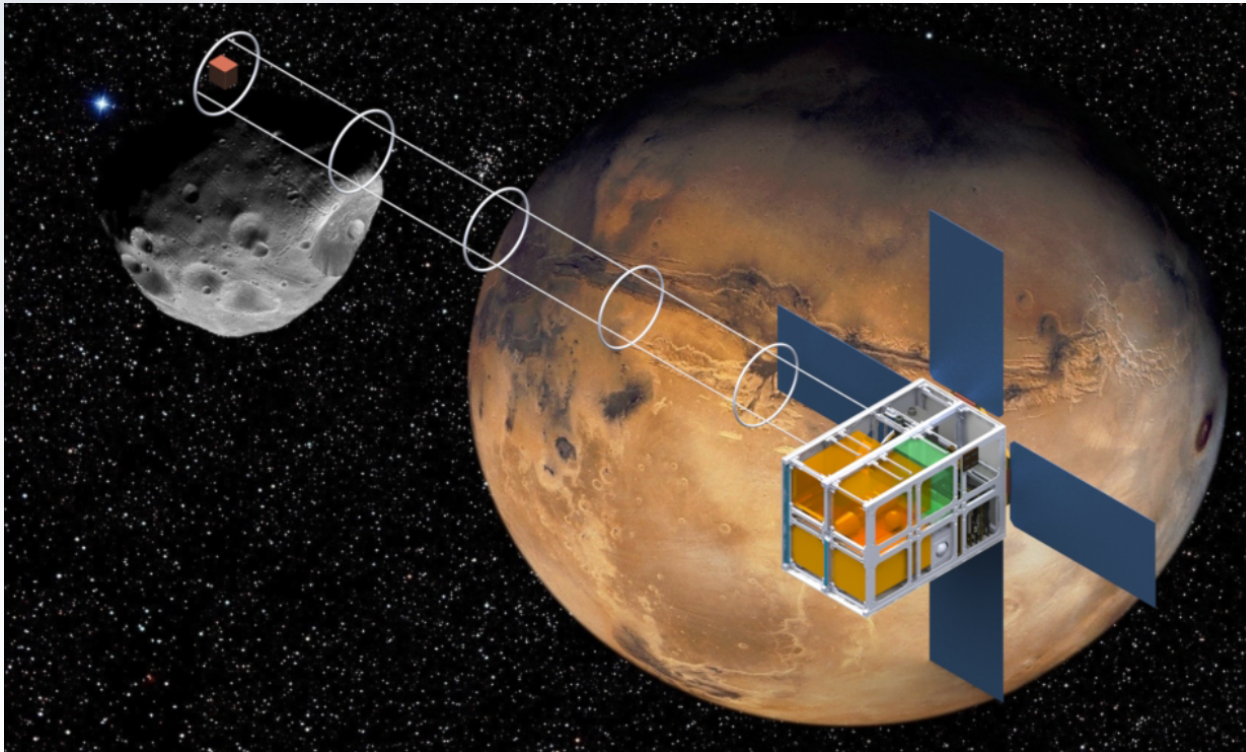


Image credit: B. Kumar, E. Srnka, S. Kuckelman, S. Chodimella, D. Ma, J. Cheung

# Summary

- A 6-12U cubesat could provide significant new information on the composition and origin of Phobos
- Could provide essential data to support a future Phobos manned mission
- Use of COTS components would enable cubesat to be ready for Mars 2020 or 2022 missions
- Might provide one of the few opportunities to gather dedicated measurements of Phobos in the next decade